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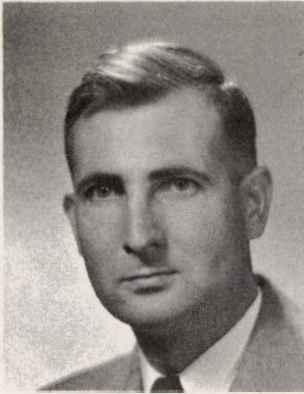
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THE AUTHORS



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ROBERT W. MERZ has been a research administrator at the Central States Station for 10 years. Before that he was engaged in the technical phases of research, chiefly in the field of strip-mined-land forestation. And before that he was a Forest Ranger. At the present time, Bob is Research Center Leader at Carbondale, Illinois. Our work there emphasizes management of upland and bottomland hardwoods and utilization of low-grade hardwoods. Merz holds bachelor and master of science degrees in forestry from the University of Minnesota and has authored nearly a score of publications dealing with various forestry subjects.

TREE SPECIES RECOMMENDED for STRIP-MINE PLANTATIONS in Western Kentucky

Stephen G. Boyce
Robert W. Merz

Ten years of observations show that at least 12 species of trees can be recommended for planting on land strip mined for coal in western Kentucky. Tests started in 1948 show that successful plantings can be made if species are properly selected for the various sites, and if good-quality stock is used in the planting.

In 1948 an area about 5 miles west of Madisonville, Kentucky was selected for test planting. It had been strip mined 6 to 8 years earlier. The spoil banks were typical of those formed from mining in the Lisman Formation^{1/} (fig. 1). In 73 subplots, each 105 x 105 feet in size, tree seedlings or seed were planted at 7 x 7 foot spacings. A total of 16,425 seedlings or seed were used (fig. 2).

Black walnut (seedlings and seed), sugar maple, and a mixture of northern red and white oaks were planted in pure stands and in 25-, 50-, and 75-percent mixtures with black locust.^{2/} Yellow-poplar and American sycamore were planted in pure stands and in 50-percent mixture with black locust. Pure plantings were made of loblolly pine, shortleaf pine, pitch pine, Virginia pine, and bald-cypress.

^{1/} Merz, Robert W. Character and extent of land stripped for coal in Kentucky. Ky. Agr. Expt. Sta. Cir. 66, 27 pp., illus. 1949.

^{2/} Common and scientific names of the planted trees are listed on page 12.



Figure 1.--Typical spoil banks of the planted area. The surface material varied from a clay loam to a coarse silty shale. Natural vegetation was sparse and scattered.



Figure 2.--The same area shown in figure 1 but 10 years after planting. Shortleaf pine is in the foreground; yellow-poplar and black locust are in the background.

BLACK LOCUST SURVIVED BEST

Half of the black locust trees planted were living after 10 years. This high survival rate is usual for black locust and makes it a useful species for obtaining a quick cover of vegetation on strip-mined land.

After 10 years the survival of trees other than locust was 41 percent or less (table 1). However, because the trees were planted at a rate of about 900 per acre, a survival of 25 percent resulted in satisfactory stocking where the trees were evenly distributed. The pure plantings of sycamore, for example, where the survival is 41 percent, are so dense they already need thinning to give ample growing space for the best trees.

Although the pine plots have average survivals of less than 30 percent, some of the stands are so dense it is difficult to walk through them. On the other hand the cypress plots, that average 34-percent survival, are quite open due to the cylindrical shape of the trees (fig. 3). Even so, the trees are well distributed and ultimately will form a closed canopy if survival is maintained.

Sycamore and yellow-poplar had less than 2-percent survival where they were planted in a mixture of 50-percent or more black locust. If the percentage of black locust had been 25 percent or less, yellow-poplar and sycamore might have been more successful. When planted in mixture with black locust, release cuttings of the locust may be needed to maintain survival of these species. While sycamore can be expected to survive sufficiently to form a good stand on a wide range of strip-mined sites, yellow-poplar should only be planted on the best sites.

In general, black walnut, hard maple, and the oaks survived best where they were planted with locust. For black walnut and hard maple, a 50-percent mixture of black locust in plantings of these species is about optimum (table 1). The oaks survived best in mixtures of 75-percent black locust.

Ten-year survival of the 4 pines was about the same. The pine planting stock was rather poor and high losses occurred the first year. Top-root ratios by weight for Virginia, loblolly, shortleaf, and pitch pine were 3.9 to 1, 4.6 to 1, 4.4 to 1, and 8.2 to 1, respectively. Good-quality planting stock normally has a top-root ratio of less than 3 to 1.

Table 1.--Ten-year survival and heights of trees planted
with black locust on strip-mined land in western Kentucky

Species	: Amount of : black : locust	: Average : survival	: Maximum : height
	<u>Percent</u>	<u>Percent</u>	<u>Feet</u>
Black walnut	0	22	16
	25	20	16
	50	32	24
	75	23	22
Sugar maple	0	22	20
	25	22	16
	50	38	30
	75	23	16
Northern red and white oak	0	10	15
	25	21	20
	50	21	18
	75	31	14
Yellow-poplar	0	24	23
	50	2	18
American sycamore	0	41	28
	50	0	--
Loblolly pine	0	28	24
Shortleaf pine	0	25	13
Pitch pine	0	25	16
Virginia pine	0	27	14
Baldcypress	0	34	16
Black locust	100	50	<u>1/</u> 40

1/ Estimated.

Figure 3.--Eight-year-old cypress.



BLACK LOCUST AND SYCAMORE GREW BEST

The tallest trees were black locust and sycamore. Most of the locust were more than 30 feet tall and most of the sycamore were taller than 20 feet. The locust is post size at present, and if current growth is maintained, sycamore will be large enough for pulpwood by the time it is 20 years old (fig. 4).

Loblolly pine was next to sycamore and black locust in rate of height growth. It surpassed the height of the other pines by 8 feet or more (table 1). It had good growth form and, for the area under study, was by far the best pine (fig. 5). Sometimes loblolly pine is damaged by frost or sleet but no such damage occurred here in the first 10 years.

The tallest trees of the other species averaged at least 1.3 feet of height growth each year during the 10-year period, indicating that excellent tree growth conditions exist on this strip-mined area. Most of the trees grew best in well-drained bottoms and on lower north- and east-facing slopes (fig. 6). Growth was slowest on the narrow ridges, on upper south- and southwest-facing slopes, and where the acidity was highest. Growth rates of many species were extremely variable. Within subplots of the same species, 10-year-old trees varied in height by more than 20 feet. Trees only 8 to 10 feet apart sometimes showed marked differences in height. This indicated that sites for the several species should be carefully selected to assure good growth. Also, because of this extreme variation, comparisons of average heights among species are of little value. The maximum heights reported in table 1 are for trees growing in well-drained bottoms and on lower north-facing slopes.



Figure 4.--One of the sycamore plots. Most of these trees were more than 20 feet tall after 10 years.



Figure 5.--Many of these loblolly pine trees were more than 20 feet tall after 10 years.

MANY NATIVE PLANTS INVADED THE PLANTINGS

Usually organic matter increases and surface temperatures moderate in spoil-bank plantations as the trees increase in size. This favors the establishment of plants that otherwise might not occur on strip-mined areas. These plants help increase organic

Figure 6.--Yellow-poplar
planted with black
locust on a lower slope.
This tree was 23 feet
tall after 10 years.



matter in the soil, reduce the rate of water runoff and surface erosion, and serve as food and cover for animals.^{3/}

More than 80 native woody and herbaceous species were found on the plots. The trees included dogwood, American elm, persimmon, sassafras, black cherry, eastern redcedar, mulberry, and redbud. Shrubs and vines included sumac, elderberry, deciduous holly, wild grape, and trumpet creeper. Herbaceous plants made up the largest number of species and included many grasses, legumes, and composites.

Plants were most abundant in stands containing black locust. Many plants also occurred under pine but there were very few under the pure plantings of hardwoods other than black locust. The frequency of understory plants in black locust stands may be due to increased nitrogen fixed in the roots of the locust^{4/} and made available for plant growth.

^{3/} Collins, F. W. Game management practices on strip-mined land. Tenth Ann. Conf. Southeast. Assoc. Game and Fish Comms. Proc.: 213-221, illus. 1956.

^{4/} Finn, Raymond F. Foliar nitrogen and growth of certain mixed and pure forest plantings. Jour. Forestry 51: 31-33. 1953.

CHOOSING TREES FOR PLANTING SPOIL BANKS

In selecting a species for planting, the planter is generally guided by the objectives of the planting and the condition of the strip-mined areas, as well as the suitability of the species. In determining suitability of a species more must be considered than just its chance of survival and expected rate of growth. Usually form of the tree on a specific site and its susceptibility to damage by rodents, insects, diseases, and other agents are important considerations. General observations of these characteristics were made for each species.

Black locust.--Black locust has proved to be valuable as a nurse crop for shade-tolerant species. However, wind movement of the thorny branches of black locust frequently caused severe mechanical damage to other trees planted in mixture with locust. Observations in southern Illinois have indicated black locust should compose 20 to 50 percent of the stand when planted with other species.

The black locust produced many new stems in the Kentucky plots by root sprouts. By this means it invaded other plots and, to some degree, stocked small areas where the original planting failed. It proved an excellent tree to plant where a quick tree cover was desired (fig. 7).

Black locust was tallest and had best form on lower slopes. Less than 25 percent of the trees in this planting were damaged by



Figure 7.--Looking between two rows of 10-year-old black locust planted 14 feet apart.

the locust borer, which sometimes causes severe damage to black locust plantations.

Black locust enriches the supply of nitrogen in the soil where it grows.^{4/} Moreover, in this area the black locust canopy and the accumulation of organic matter in the plots undoubtedly insulated the soil against rapid temperature changes and slowed evaporation and runoff. For these reasons black locust was a desirable species to use in the initial planting.

Black walnut.--Both seedlings and seed can be used to establish black walnut on strip-mined land. In this study black walnut from seed grew as fast or faster than planted seedlings. This species grew slowly during the first 5 years, but between the 7th and 10th years most of the trees averaged 1 to 2 feet of height growth per year. On lower slopes and in bottoms many of the stems were single, straight, and had good crowns. When planted with black locust, many terminal shoots of walnut were mechanically injured by whipping from the thorny locust branches.

Growth and survival of walnut were best on lower slopes and in bottoms in mixture with black locust. It was not suitable for planting in pure stands (fig. 8). Some of the trees showed evidence of rodent damage, but no insect or disease damage was observed.

Sugar maple.--The best growth, survival, and form of sugar maple were found where it was grown in mixture with black locust on lower slopes and well-drained bottoms. Under these conditions many maples had single, straight, well-formed stems; on ridges, upper slopes, and in pure plantings, more than half of the trees had multiple stems.

No insect or disease damage was noticed on this species. Rodent damage was present on some trees.

Red and white oaks.--More oaks survived in mixed plantings where 75 percent of the trees were black locust, but the oaks grew best in mixtures of 25- to 50-percent black locust (fig. 9). On lower slopes and in bottoms most of the oaks had single, straight stems.

Sycamore.--This was one of the best hardwoods for planting in pure stands and grew well on a wide range of spoil-bank conditions. More than 90 percent of the sycamore had single, straight stems of good form. This species failed where it was planted in locust mixtures.



Figure 8.--In pure stands black walnut grew slowly.



Figure 9.--Northern red oak planted with black locust. After 10 years many of the oaks were more than 13 feet tall. The black locust in this plot was more than 30 feet tall and 3 to 4 inches d.b.h.

No disease or insect damage was observed in this planting; however, Anthracnose (Gnomonia veneta) has attacked sycamore on other strip-mined land in adjoining states.

The generally good survival, rapid height growth, single-stem form, and tolerance to a wide range of acidity made sycamore a good species for planting on these spoil banks. Sycamore grew best when planted in pure stands.

Figure 10.--On upper slopes and ridges these yellow-poplar trees made slow growth and had poor form. Yellow-poplar does best on well-drained bottoms and in mixture with black locust.



Pines.--The pines were established successfully on upper slopes and ridges, but the best growth was on lower slopes and well-drained bottoms. Virginia pine had very poor growth form, and limbs on many trees extended to the ground. Virginia pine and shortleaf pine suffered from heavy attacks by tip moth (Rhyacionia spp.) which resulted in rounded or globe-shaped crowns. Damage to loblolly pine and pitch pine by tip moth was minor.

Loblolly pine and pitch pine had the best form among the pines. They were planted on moderately acid to acid areas (pH 6.5-4.5) and grew better on the ridges and upper slopes than most hardwoods.

Baldcypress.--Relatively little baldcypress has been planted on strip-mined land. After 10 years about 20 percent of the trees in this planting had straight stems with conical crowns. Many trees grew slowly in height and some had flat crowns. Many bagworms (Thridopteryx spp.) were observed on the baldcypress and a few trees had been almost completely defoliated.

Yellow-poplar.--This valuable species grew best only on the good sites, such as well-drained bottoms near small ponds and on lower slopes that contained a high percentage of sand. On upper slopes and ridges the trees had flat crowns and poor form (fig. 10). Many trees showed rodent damage but no insect or disease injury was noted.

This species should not be used in extensive plantings on ridges but can be used for small plantings on lower slopes, well-drained sandy bottoms, and on other moist sites. Yellow-poplar should constitute more than 75 percent of the stand when planted with black locust.

SUMMARY AND CONCLUSION

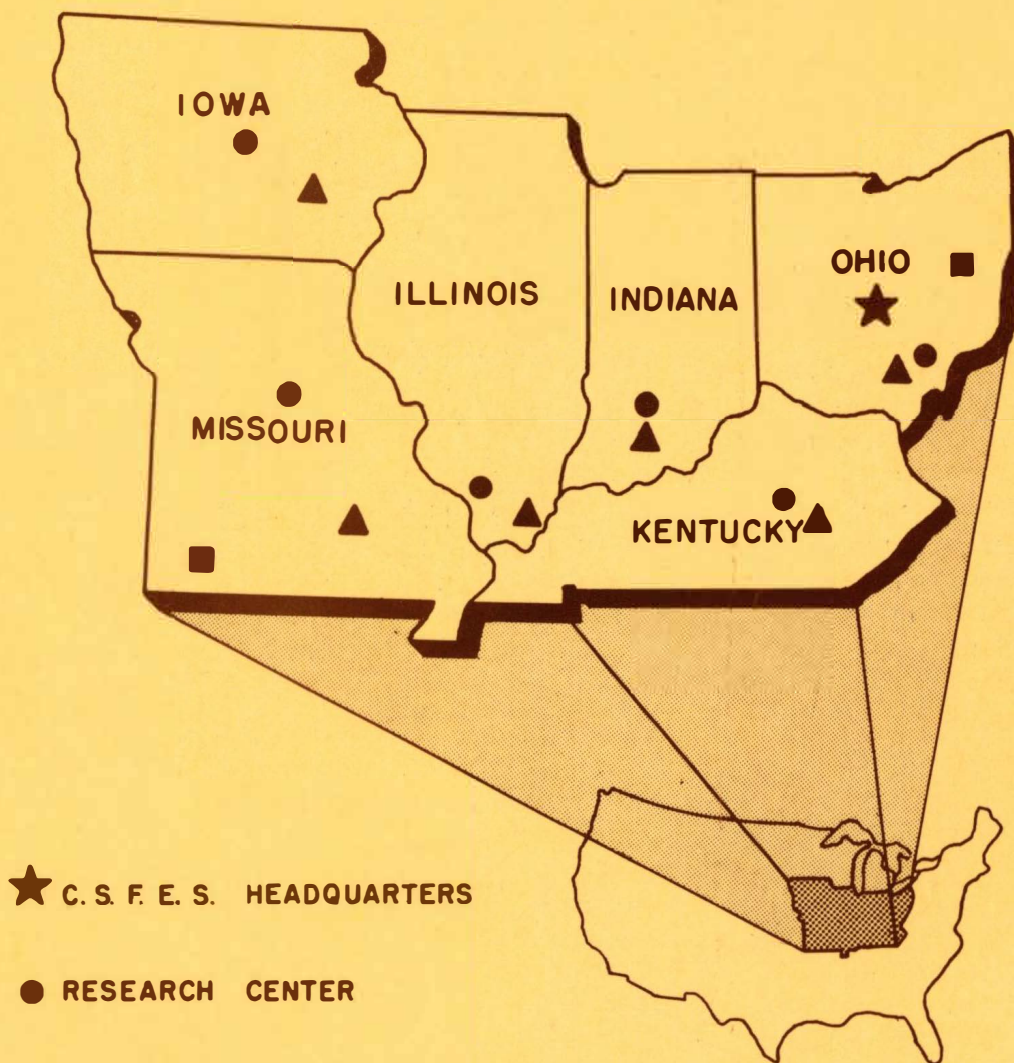
Twelve species of trees were planted on strip-mined land in western Kentucky. All were found to be suitable for planting, either in pure stands or in mixture with black locust, on at least some spoil-bank sites. Survival and growth varied widely among sites and species. For best survival and growth, species should be carefully selected for the various sites and only the best quality stock should be planted.

TREE SPECIES MENTIONED

(According to Agriculture Handbook No. 41,
"Check List of Native and Naturalized Trees
of the United States," 1953.

American sycamore	-	<u>Platanus occidentalis</u> L.
Black locust	-	<u>Robinia pseudoacacia</u> L.
Black walnut	-	<u>Juglans nigra</u> L.
Baldcypress	-	<u>Taxodium distichum</u> (L.) Rich.
Loblolly pine	-	<u>Pinus taeda</u> L.
Northern red oak	-	<u>Quercus rubra</u> L.
Pitch pine	-	<u>Pinus rigida</u> Mill.
Shortleaf pine	-	<u>Pinus echinata</u> Mill.
Sugar maple	-	<u>Acer saccharum</u> Marsh.
Virginia pine	-	<u>Pinus virginiana</u> Mill.
White oak	-	<u>Quercus alba</u> L.
Yellow-poplar	-	<u>Liriodendron tulipifera</u> L.
Flowering dogwood	-	<u>Cornus florida</u> L.
American elm	-	<u>Ulmus americana</u> L.
Persimmon	-	<u>Diospyros virginiana</u> L.
Sassafras	-	<u>Sassafras albidum</u> (Nutt.) Nees
Black cherry	-	<u>Prunus serotina</u> Ehrh.
Eastern redcedar	-	<u>Juniperus virginiana</u> L.
Red mulberry	-	<u>Morus rubra</u> L.
Eastern redbud	-	<u>Cercis canadensis</u> L.

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